Shock and Its Treatment

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THOUGH shock is due to many different causes, the clinical appearances are more or less constant; they vary only in degree, and are easily recognized in the more severe cases. The symptoms are increased pulse-rate, low blood-pressure, pallor, subnormal temperature, sweating, vomiting, thirst, and dry tongue; the mind is usually quite clear. In addition to the pallor, the skin of the ears and lips may show slight cyanosis. The signs are due to profound changes in the nervous, circulatory, and respiratory systems, and in the temperature-regulating mechanism. The amount of the fall in the blood-pressure and the reduction in volume of the circulating blood vary directly with the clinical condition, and indeed give a good quantitative estimate of the degree of shock present. As a result of study, in the last Great War, of the total blood volume and of the relative volume of red cells and plasma, using the vital red method and the hæmatocrit respectively, Keith[1] has divided shock into three stages according to its severity.

Group 1.—Mild shock, in which the condition is good. There is a history of a not too severe injury or of a moderate primary hæmorrhage. On examination, there is some pallor, the pulse is 90-110, the systemic blood-pressure is over 95 mm., and the blood-volume is never below 75 per cent. These may be called compensated cases.

Group 2.—The general condition is serious. The extremities are cold and clammy. The pulse is 120-140, the blood-pressure is 70-80 mm., the blood-volume is 65-75 per cent., and the volume of the red cells is increased relatively to that of the plasma. These cases are partially compensated.

Group 3.—These cases are dangerously ill. The pulse is almost impalpable, the blood-pressure is below 60 mm., the blood-volume is less than 65 per cent., and on auscultation, the heart-beat is 120-160 per minute. They are not compensated.

It is important to recognize to which group the patient belongs and to treat accordingly. The divisions suggested by these groups are not hard and fast. Intermediate stages occur, and an individual may and often does pass through two or even all three stages in a short time.

Prior to the Great War of 1914-1918, the changes occurring in shock were not fully understood, but observations made then, and much painstaking work by experimental workers carried out since under controlled conditions, have shown many of the factors involved, and have indicated the lines along which rational treatment should lie. It is unnecessary to recapitulate the various theories of shock which have been held, but it may be advantageous to consider briefly how the present conception of shock has been obtained. The great fall in blood-pressure impressed the earlier observers and formed a starting-point for investigation. The fall in pressure might be due either to a loss of peripheral resistance or to a diminished cardiac output. The former, thought to be due to a loss of vaso-constrictor tone, has been shown not to exist. The peripheral vessels are actually in a state of constriction; in other words, the sympathetic nervous system, instead

of being paralysed, is in a state of activity, further proof being afforded by the sweating, the pallor, and the dilated pupils, all of which are due to stimulation of the sympathetic nervous system. The fall in blood-pressure occurring with contraction of the arterioles must then be due to a diminished output from the heart, and this in turn to a reduced intake from the great veins, as the heart itself is normal. However, in time the lowered intake means less blood in the coronary circulation, and the cardiac factor now adds its quota to the reduction in the amount of blood in circulation. The fall in blood-pressure is now therefore accepted as being due to a reduction in the blood-volume, and this reduction is the cause of all the serious symptoms as well as the progressive deterioration in the patient's general condition, which are so characteristic of shock.[2] The restoration of the blood-volume is the fundamental principle of treatment. The loss of blood-volume is due in part to stagnation of blood in capillaries and venules and of muscles and viscera, and also to an actual loss of plasma through the capillary wall. This results in a relative increase of red cells over plasma in the capillaries. The concentration of the corpuscles in the capillaries increases the viscosity of the blood and tends to slow an already sluggish stream, thereby still further reducing the volume of circulating blood. It has been held that the circulatory changes are due to the liberation of histamine from the damaged tissues, but recently Blalock[3] (1934) has brought forward evidence that approximately one-half of the total blood-volume may be lost in an injured extremity, and that this loss is sufficiently great to account by itself for the decline in the blood-pressure. He injected fluid from an animal in a state of shock into another animal, and found that the blood-pressure of the second animal did not fall, but rose.

The vaso-constriction found in cases of shock is evidently nature's attempt to maintain the blood-pressure in the presence of a reduced volume. The vaso-constriction is more or less effective for a fluid loss up to about two pints, but when the loss is greater, the compensation fails and the blood-pressure falls to 60 mm. or less (Keith's third group). The vaso-constriction, the reduced blood-volume, and the low blood-pressure, together produce a totally inadequate circulation to all parts, so that the nervous system, the viscera, and even the endothelium of the blood vessels suffer from severe lack of oxygen and nutritive substances. If continued, this damage is irreparable, hence the importance of instituting early and adequate treatment. Blood or plasma injected after the endothelium has been damaged is not retained in the circulation (except, of course, the cellular elements); transfusion in such a case is therefore of no avail, and may actually be harmful.

TREATMENT.

It follows from the above considerations, that the treatment of shock should be started early, preferably before it has become manifest, or at least in its early stages, and that the restoration of blood-volume is the essential step in preventing that worsening of the patient's condition which is such a characteristic feature of shock. In addition to this main requirement of restoring the blood-volume to near a normal figure, attention may be drawn to certain subsidiary factors, each aggravating shock to some degree, and in the aggregate of considerable importance. They are exposure to cold and fatigue, hæmorrhage, pain, lack of

fluid and oxygen, infection, and wounds of special parts of the body. These factors will be considered briefly first of all.

Injuries, and particularly war injuries, often occur under the worst conditions of cold, wet, and fatigue. Wet clothing should be removed and replaced by warm and dry clothing. The patient should then be placed in a bed warmed by jars or an electric blanket and the foot of the bed raised. Apart from the movements necessary for the change of clothes, the patient should be kept as still as possible, and all elaborate examinations or unnecessary manipulations carefully avoided.

A tourniquet should be applied only in cases of severe hæmorrhage, and should not be retained for more than an hour or so—under normal working conditions—unless the limb is obviously beyond saving. For a limb not hopelessly damaged, a firm bandage applied over plenty of wool is preferable to a tourniquet, and is equally effective in preventing blood- and plasma-loss into the damaged tissues.

Pain is a potent factor in maintaining and increasing shock. Its relief is of the first importance, and is easily obtained by the use of morphine. The first dose may be $\frac{1}{4}$ to $\frac{1}{3}$ grain, given preferably subcutaneously or intramuscularly for speed of effect, and repeated every four or six hours as indicated. In bad cases of shock, the circulation may be so poor that morphia given subcutaneously may not be carried to the central nervous system in a reasonable time. An almost immediate action can be produced by giving $\frac{1}{4}$ grain of morphine dissolved in 1 c.c. of sterile water intravenously.[4] One minute or more should be taken for the injection.

Not only do wounded men lose water by perspiration, but they often have less than the normal amount of body fluids before being wounded, particularly if they have undergone much physical exercise in dry weather or hot climates. The loss of water and salt should be made good as soon as possible. The mouth is the natural route for the intake of fluid, and the greatest use must be made of it by encouraging the patient to drink much and often. Water containing half a teaspoonful of salt to the pint, and even normal saline (one teaspoonful to the pint) has a scarcely perceptible salty taste. Haldane found that coal miners in the deep pits at Salford perspired heavily at their work, and when given saline, drank by the quart and asked for more! Warm drinks, for example coffee and tea, may be given as frequently as possible. When fluids cannot be taken by mouth, they should be given by the rectum, subcutaneously, or intravenously. Isotonic saline, glucose, or preferably Ringer-Locke solution warmed to body temperature, may be used. As these fluids soon pass out of the circulation, it is of advantage to give them slowly and over a considerable period by the "continuous drip" method. In bad cases, blood or plasma may be given before or with the saline.

Oxygen is of value in cases where cyanosis can be detected, and particularly in wounds of the chest, in cases with pulmonary œdema, and in poisoning with carbon monoxide. To be effective, the oxygen must be given by an apparatus which will appreciably raise the oxygen tension in the lung alveoli, from the normal fourteen per cent. to seventy per cent. or more. The Boothby, Lovelace, and Bulbulian apparatus is recommended.[4] It consists of a mask, a connecting device, and a reservoir breathing-bag. Raising the carbon dioxide in the inspired air to about five per cent., either by rebreathing or by adding carbon dioxide to the oxygen,

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causes deeper breathing, and is an important method of increasing the amount of the tidal air. Carbon dioxide is especially indicated in cases of carbon monoxide poisoning, e.g., from coal-gas or explosions in enclosed spaces.

The degree of shock depends not only on the extent of the injuries received, but also on their nature and on the parts injured. Of special importance in this connection are burns, head injuries, wounds involving the spine and spinal cord, and wounds of the chest, especially open pneumothorax and wounds of the pericardium. Open chest wounds are associated with a high mortality unless quickly sealed; indeed, closure of such wounds should be carried out immediately, even if only by a few interrupted sutures in the skin. Burns, as is well known, cause shock, the degree of which bears a relationship to the area of the burn rather than its depth. Shock from burns is now regarded as identical with that due to wounds, and the treatment is the same.

The question of operation has to be considered in certain cases. When operation can be postponed until shock has been successfully combated, the answer is obvious; but in the remainder it must be left to the judgment of the surgeon in each case how much is to be gained by operating in the presence of shock or by waiting for a time until the shock has been partially or completely treated. This remainder includes depressed fractures of the skull, wounds of the chest, especially if there is an open pneumothorax, and extensive wounds with hæmorrhage or gross infection. Amputation may be considered in hopelessly mutilated limbs; and incision for infection, followed by the administration of drugs of the sulphanilamide group and the appropriate anti-sera. When it has been decided to operate, due consideration should be given to the choice of the anæsthestic. Ether may be given in short cases, but in prolonged anæsthesia it is in itself a potent cause of shock. Nitrous oxide and oxygen is free from this defect, but it requires skill to give good anæsthesia with a minimum of anoxæmia.

Actual experience of recent air-raid casualties has shown the value of determining the degree of shock and instituting the appropriate treatment. Early operation, particularly the amputation of badly mutilated limbs, has been associated with a high mortality. The number of cases requiring prompt operation for excessive hæmorrhage has been surprisingly small, being less than five per cent. of the total injuries.[5]

As follows from the physiological changes occurring in shock, the restoration of the blood-volume is the logical and fundamental element in the treatment of all but the lesser degrees of shock, and should be attempted as soon as the patient is in bed and the general measures have been or are being carried out. The fluid which was originally used intravenously for this purpose was blood. Its use in a large scale in the war of 1914-1918 and since then has been instrumental in saving many lives. It remains the fluid of choice in those cases where shock is due primarily to hæmorrhage. The original routine amount of one pint is usually insufficient, and can be increased advantageously to two, three, or four pints. The blood may be fresh or preserved.[6] In cases of shock not due to bleeding, the red cells are increased relatively to the plasma; and the viscosity of the circulating fluids is increased. The addition of more red cells is therefore undesirable. Gum

saline was introduced for this and other reasons, but its use has been largely discontinued on account of accidents. It was only recently that the obvious and natural fluid for transfusion in such cases has been used, namely, human plasma or serum.[7] Even in hæmorrhage, the restoration of the blood-volume and its maintenance by the osmotic pressure exerted by the proteins of the injected plasma have been found to be of great value. Plasma is produced at the Royal Victoria Hospital from blood which has not been required for use within its normal keeping time. To 150 c.c. of 5 per cent. glucose in doubly distilled water and 50 c.c. of 3.8 per cent. sodium citrate are added 350 c.c. of blood. The citrated blood is stored in the refrigerator for ten or twelve days. If not used within this time the plasma is decanted off, and is capable of being stored indefinitely at four degrees centigrade. The plasma may be dried to the powder state, in which it will keep even longer at room temperature.[8] The powder is prepared again for injection by the addition of sterile distilled water or glucose saline.

The intravenous injection of plasma is of greatest benefit in cases of shock belonging to Keith's group 2 (see above). In group 1 the general measures of rest, heat, morphine, and fluids indicated earlier are usually all that are necessary. Patients in group 3 are practically beyond help from any treatment, because in these people the endothelium of the blood vessels has been so damaged that it is no longer able to retain even the plasma proteins, emphasizing the importance of recognizing shock in its earlier stages and treating energetically.

The clinical course of each case of shock should be checked as frequently as possible, at least hourly. The patient's colour, the temperature of the extremities, the strength and rate of the pulse, and the blood-pressure all give indications of his progress. If facilities are available, red-cell counts and hæmoglobin estimations are also of value. Injection of plasma should be repeated and the general measures maintained until the patient's condition is satisfactory.

In conclusion, stress may be laid on the importance of recognizing shock in its early stages and of starting effective treatment immediately. The essentials of treatment can be summarized as follows:—Rest with a minimum of interference for any reason, dry warmth, morphine for the relief of pain, plenty of fluids by the mouth or other routes, operation in only a few special cases, oxygen for cyanosis, and the intravenous injection of two to four pints of blood or plasma, repeated if necessary, in all cases where the amount of shock is not slight, and if the fall in the blood-pressure and the rise in the pulse-rate is progressive. For details of the technique of injection and a description of the B.L.B. apparatus for the administration of oxygen, the Medical Research Council's War Memorandum No. 1 is recommended.[4]

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